Towards the Quality Factor of Software Maintenance Process: A Review

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***Abstract*—Software maintenance (SM) is classified as the common process of modifying a system or software product once it has been delivered to user. Different type of process applied to different type of applications and in certain stages of the processes involve adding new components to the existing system. Software maintenance process is a series of actions taken to overcome changes during the maintenance phase. To ensure the sustainable quality of software product throughout the software life cycle, a good mechanism in software maintenance process should be implemented. Most organization nowadays depend on software products to run their business operations. Thus, it is crucial to ensure the software applications operating in the organization are sustainable while preserving its quality in a long run. The kick-off study starts with identifying the quality factors related to maintainability dimension that affected software maintenance process. A comprehensive literature study is conducted to find related processes within maintainability sub-factors. The identified factors will be evaluated by practitioners who involve in maintaining process. The maintainer personnel help to prioritize the task and eliminate the insignificant activities during maintenance process. This paper focuses on maintainability quality factors and its sub-characteristics impact on software maintenance process.**

***Index Terms*—Maintainability Quality Factor; Maintenance Process; Software maintenance.**

I. Introduction

Organizations nowadays rely on software product to run their business operations more effective and efficient. Thus, for any software product to sustain in a long run, a good maintenance processes are needed. In software development life cycle, software maintenance takes part after software product has been delivered to user. Consider as the most expensive activity, maintenance phase also is considered as the tedious part in software lifecycle [1].

Software maintenance is an important stage in software life cycle to ensure the software product being delivered to the user still maintain its' requirement and satisfaction [2]. Since software maintenance has been seen as a service delivered to customer, it must be able to provide excellent services while preserving its quality. Nevertheless, the task in software maintenance especially to maintain the software product is very challenging and potentially costly [3].

The maintenance process involved all activities needed to keep the software operational and satisfy user requirements [4]. Changes in user requirements occur from time to time during the operation of the software. This will invoke the process of software maintenance. Software maintenance process generally a sequence of steps that been carried out by a machine or staff or by both [5].

Basically, maintenance process depends on the type of software being maintained. It is important to identify the nature of software maintenance process and come out with the best mechanism to maintain the software product. There are six activities that comprise maintenance process as presented by ISO/IEC [6]. The activities are process implementation, problem and analysis of modification, implementing the modification, reviewing or accepting maintenance, migration and finally retirement. Each activity will have its own tasks and then will map to maintainability attribute. Quality of maintenance is the focal point that in charge for successful and long service of application software [7]. In long-term project or an open source project, it is important to provide a high-quality software after maintenance to user.

The main objective of this paper is to identify the quality factors in software maintenance process related to maintainability characteristic. Maintainability requirement is crucial to users and maintenance personnel towards determining the effort to identify the reason for software failures and to verify the success of the correction [7]. Maintainability consist five sub-characteristics that representing the ability of the software to be changed [8]. The maintainability sub-characteristics will be discussed and presented in this paper.

This paper is structured as follows; Section II reviews the software maintenance process. Section III presents the analysis and Section IV provides some discussions. Finally, Section V concludes this paper.

II. Background of Study

Software maintenance is considered as a costly phase where estimated cost of software maintenance phase is around 40% to 90% of the total budget of software projects [9]. Immediately after a system been released to customer or user for the first time, then the software maintenance phase begins. In general, software maintenance is referring to a group of activities that are performed in order to keep a system functioning, as software keep on changing after the system being deployed [10]. Figure 1 illustrates the general activities done during software maintenance process [11].

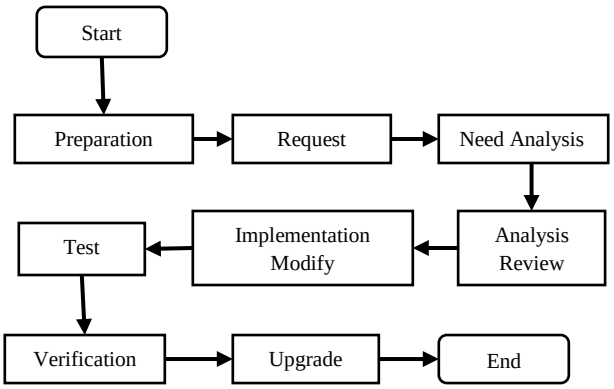

Figure 1: Software Maintenance Process [11]

Based on Software Engineering Body of Knowledge (SWEBOK), maintenance types are comprised of corrective maintenance, adaptive maintenance, and perfective maintenance. While IEEE 14764 added fourth category of maintenance as preventive maintenance. The software maintenance categories illustrated in Table 1.

Table 1
Software Maintenance Categories

	Correction	Enhancement
Proactive	Preventive	Perfective
Reactive	Corrective	Adaptive

Each types of maintenance are responsible with activities that focused on keeping the system usable and valuable for the company [12]. Different maintenance process are applied in each type of maintenance categories.

Many researchers agree that software maintenance process compromised more than half of the development process and been classified as a dense task [13]. SWEBOK [14] define software maintenance as the complete activities that intended to provide software support economically. IEEE 14764 describes maintenance processes as a set of activities with detailed input and output [15]. The software maintenance process as describes by IEEE 14764 are depicted in Figure 2.

Since this study focuses on post-delivery activities, definition of software maintenance process by IEEE is the most suitable. There are a few models related to software maintenance process models as presented by SWEBOK and they are:

i. Quick fix
ii. Spiral
iii. Osborne's
iv. Iterative enhancement
v. Reuse-oriented.

Unfortunately, Mira Kajko [15] and Zeljko et al [16] claim that there is still lack of maintenance process model since none of the process model can provides a specific solution to each type of maintenance. It is important to evaluate various parameter since product and service quality are influence by maintenance process [17].

However, in [18], all maintainers personnel must aware with the characteristics of different models and decision must be based on the preserved environment. Despite the availability of the models, the quality of the maintenance process should be taken into maintainers' consideration. Maintainability is one of the software quality factors and previous study has revealed that it will decrease over time along the operation [19].

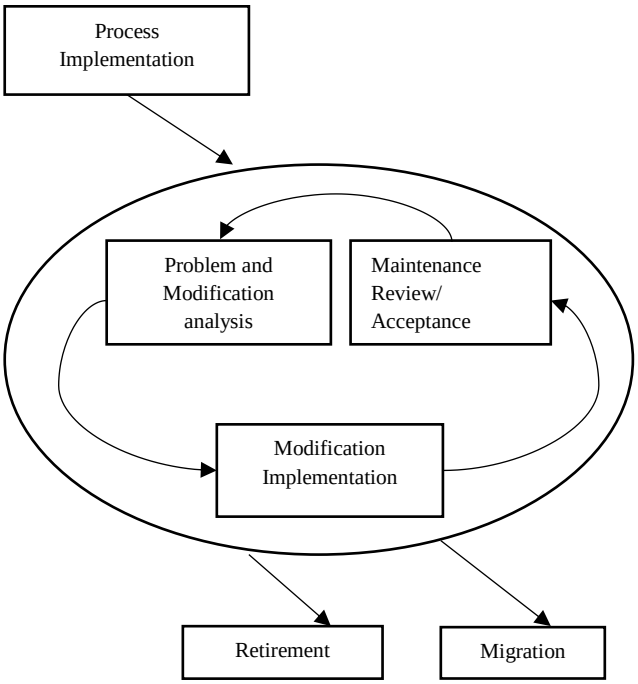

Figure 2: Maintenance Process by IEEE 14764 [15]

In this paper, an intensive study done to find list of quality factor related to maintainability together with the sub-characteristics of the factor. This task will be based on users' dynamic environment that direct and indirectly influence the maintenance process. Maintenance process is influenced by many factors which will result a significant impact to final product quality [3]. Hence, to maintain software maintenance process, it is crucial to discover and recognized the related challenges.

III. Research Approach

This section elaborates on the activities followed in order to identify the list of quality factors in software product. Figure 3 demonstrates the activities throughout the process of extracting quality factors in software maintenance process.

The activity works as follows: a critical literature review will be conducted extensively. Then, list of quality factors related to maintainability will be sorted out and identified. Available software maintenance process models are compared to match with the maintainability quality factor. Next, duplicate factors will be removed. Appropriate name will be given to replace the redundancy of quality factors.

The list of quality factors will be analyzed and reviewed by the maintainers in selected organization. The experts are requested to validate these quality factors identified in preliminary list. Finally, a classification of quality factors based on industrial and expert's practices and perspective will be identified.

The result which will be the classification factors is vital for the next input of a proposed framework. This will apply as the appropriate maintainability quality factors to ensure the effectiveness of software maintenance process from both literature review and industrial's perspectives.

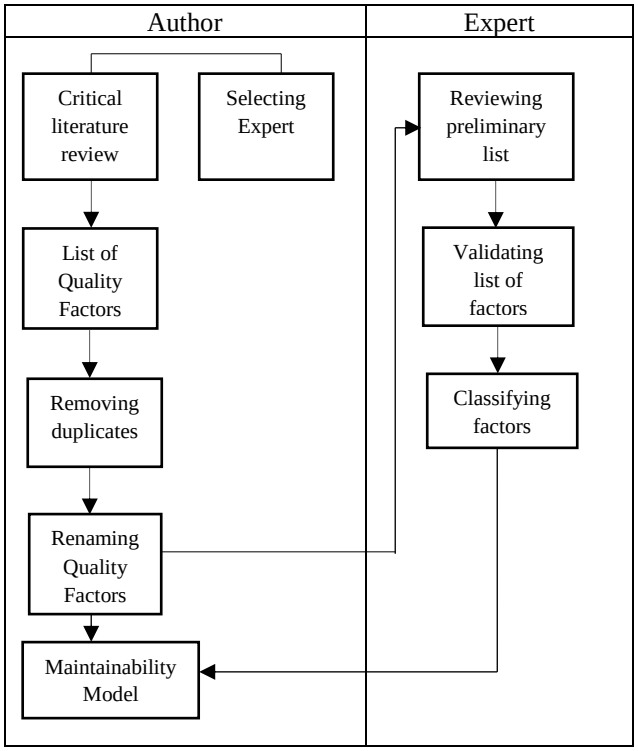

Figure 3: Activities follows in extracting software maintenance quality factors

This proposed approach aims to come out with a set of quality factor and its related task within their sub-characteristics. The expert point of view is really important to validate the task from expert and industrial's perspective and thus needed to proceed with model development

IV. MAINTAINABILITY QUALITY FACTOR

In recent years, the importance of having a good quality of software has become a central issue. Most organizations, considered software as their one of main assets to remain competitive in business [20]. Thus, there is an urge to have a high quality of software and remain competitive in their field. A good quality of software is determined by its quality characteristics that capable to satisfy users' requirement. In addition, quality characteristics becomes the universal factor that affect run-time behavior, system design, and user experience [21]. A proper maintenance process is crucial to govern different quality factors in a right way. Besides, maintainers need to have a good knowledge of software maintenance and understood its impact on quality factor.

Based on McCall model of software quality factor, maintainability is one out of three quality factors that comprise the product revision category [7]. As defined by ISO 9126 in [4], maintainability consists of five sub-characteristic which are analyzability, changeability, stability, testability, and maintainability compliance [4]. Each of the sub-characteristic are defined in Table 2. To have a good quality of software is vital and increasing in software complexity will have an impact to its maintenance process.

In this study, maintainability will be the chosen quality factor to dwell in and find the appropriate sub-factor influenced. The findings from this study then will provide some general ideas and overview about the way the maintainability affects software maintenance process.

Table 2
Maintainability Sub-Characteristics [4]

Sub-characteristic	Measurement
Analyzability	The ability of software product to be analyzed for scarcities or root of failure in the software, or for the components to be changed to be recognized.
Changeability	The ability of the software product to allow any specified changes to be executed.
Stability	The ability of software product in avoiding unanticipated effects from software changes.
Testability	The ability of software to allow changed software to be approved.
Maintainability compliance	The ability of software product to follow to standards or changes related to maintainability.

A maintainable software product will ensure for successful service in a long run. Therefore, a good maintenance process is needed during its operation period. The main factor that responsible towards successful service is the quality of maintenance [7].

A high quality of maintenance process should conform to software maintenance quality assurance activities. Galin in [7] explained the objective of software maintenance quality assurance activities as the following:

i. Activities related to software maintenance should comply with functional technical requirements.
ii. Software maintenance activities conform to management scheduling and monetary requirement.
iii. The effectiveness of software maintenance and SQA activity are improved and increased by initiating and managing activities related.

The foundation of high quality of software maintenance relies on the quality of the product too. If the product is in poor quality, maintenance will be poor or ineffective by definition. Effort to guarantee the quality of maintenance should start in early development of software product due to deterioration of software quality will give significant impact on software maintenance component. Table 3 shows the impact on software maintenance component by quality factor [7].

Table 3
Quality factors: impacts on the type of software maintenance [7]

Quality Factor	Software Maintenance Components		
	Corrective	Adaptive	Functionality improvement
Maintainability	High	High	High
Reliability	High	n/a	n/a
Flexibility	n/a	High	n/a
Testability	High	n/a	n/a
Portability	n/a	High	n/a
Interoperability	n/a	High	n/a

A new version of software quality model which is ISO/IEC 25010:2011- Software Engineering: Software Product Quality Requirements and Evaluation (SQuaRE) is also being studied as a baseline of this study. The SQuaRE model established from improvement and enhancement version of previous ISO/IEC 9126 with two newly added characteristics. The new characteristics are compatibility and security [22]. The organization of ISO/IEC 25000 series of standards is illustrated in Figure 4 [23].

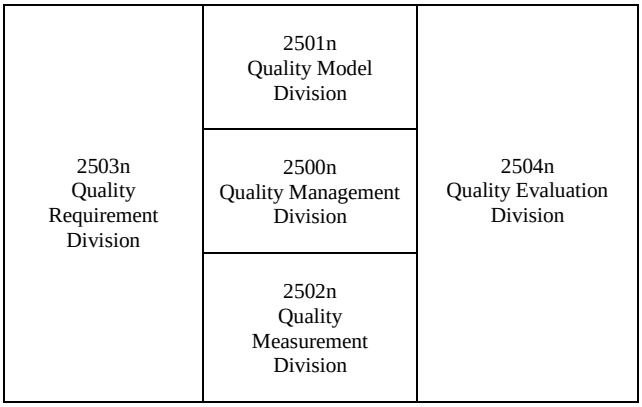

Figure 4: ISO/IEC 25000 SQuaRE series of international standards [23]

Even though the maintainability in ISO 9126 series is viewed from the product quality perspective [24], it will give a significant impact on maintenance process in the future. Also with reference to quality in use in ISO/IEC 25010 that comprises effectiveness, efficiency and satisfaction in use, it is anticipated to give a new dimension in maintaining a software [25]. As a nonfunctional requirement, maintainability is an important part in system development whereas it still needed to be preserved after any modification made on the system.

V. CONCLUSION

Software maintenance process starts after the distribution of software products to customer or user and it will keep on processing until the retirement of the software product. There are several vital and essential activities in software maintenance as presented in this paper. The result of this preliminary study has presented as an initial information for a wider study that intend to investigation a good mechanism for maintaining software throughout its lifecycle.

This study adopts ISO 9126 model of software maintainability as the reference in software quality. However, the new ISO model which is ISO/IEC 25010 will also being studied and considered in this work in future. In this paper, the ultimate aim is to provide the quality factors which will improve the quality of software maintenance process and to ensure the normal software product. Future work will establish the maintenance process model that adhere to maintainability quality factors and its characteristics.

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